the brightness remaining on the north polar regions is not uniform, but is tinged with large dusky spaces, of a cloudy atmospheric appearance. From which, and the fore-mentioned changes of colour at the polar regions, added to the changes he has formerly observed in the belts, we have, he thinks, sufficient reason to infer the existence of a Saturnian atmosphere.

The Bakerian *Lecture, on some chemical Agencies of Electricity. By* Humphry Davy, *Esq. F.R.S. M.R.I.A.* Read November 20, 1806. [*Phil. Trans.* 1807, *p.* 1.]

The chemical effects produced by electricity have, Mr. Davy says, long been objects of attention; but the novelty of the phenomena, their want of analogy to known facts, and the apparent discordance of some of the results, involved the inquiry in obscurity.

It was very early observed, that acid and alkaline matter appeared in water acted upon by a current of electricity; but Mr. Davy soon found that the muriatic acid came from the animal or vegetable matters employed to connect the two portions of water; for when the same cotton was repeatedly used, it ceased to be evolved. The soda, in like manner, was found to proceed from the corrosion of the glass tube, as it did not appear in water electrified in an agate cup.

To be more certain of this effect, some distilled water was electrified in two agate cups, by the current from 150 four-inch plates, the communication between the cups being formed by moistened amianthus. In the first experiment soda was produced in the negative cup, but the quantity was much less than when glass tubes were used; and on repeating the experiment, its quantity decreased, so that in the fourth experiment the presence of soda was scarcely perceptible in the residual water. The water in the other tube was sour, and appeared to contain nitrous acid, with excess of nitrous gas. As similar effects were produced by electrifying water in small gold cones, Mr. Davy suspected that some minute portion of saline matter had been carried over during the distillation of the water; notwithstanding it did not affect nitrate of silver, or muriate of barytes. And on evaporating a quantity of it in a silver vessel by a heat not exceeding 140° Fahrenheit, a small residuum was actually left, which appeared to be a mixture of nitrate of soda with nitrate of lead. A portion of this residuum being added to water electrified in the usual manner, and which had attained the maximum of its effect upon turmeric paper, considerably increased those effects.

Water slowly distilled, being electrified either in gold cones or agate cups, did not evolve any fixed alkaline matter, though it exhibited signs of ammonia; but in tubes of wax, both soda and potash were evolved, and the acid matter in the positive cup was a mixture of sulphuric and muriatic acids. In a tube of resin the alkali was principally potash. In cups of Carrara marble, primitive marble from Donegal, argillaceous schist from Cornwall, serpentine from the Lizard, and grauwacke from North Wales, soda was uniformly evolved.

This probably arose from a minute portion of common salt being contained in them, for the Carrara marble yielded a sensible quantity on analysis; and on repeating the electrifying of the water in the cup formed of it, the presence of soda became less visible every time, and at length disappeared entirely; but the production of lime-water was uniform. A bit of glass added to water, which was electrifying in the gold cones, caused it to exhibit almost immediately the presence of soda.

In every instance nitrous acid was uniformly found in the positive cup, which appeared to proceed from the combination of nascent oxygen with the nitrogen of the common air absorbed by the water. The longer the operation was continued, the more acid was produced, arising from the air which continued to be absorbed. Volatile alkali was also constantly formed, from the combination of the nascent hydrogen with the nitrogen; but it soon attained its utmost limit, as hydrogen during its solution in water seems to expel nitrogen. When water was electrified in vacuo scarcely any nitrous acid, and no volatile alkali, was formed. When electrified in a receiver filled with hydrogen (the common air originally contained in the water having been extracted by the air pump), neither nitrous acid nor volatile alkali was found in the water.

In all these processes, the acid matter collected in the water round the point transmitting the electricity, and the alkaline matter round that which received it. When water was even electrified in two cups made of sulphate of lime, it was found that the water connected with the positive wire contained sulphuric acid, while that in the other cup was a pure and saturated solution of lime. Similar effects were produced when use was made of cups of sulphate of strontian, fluate of lime, or sulphate of barytes. It also appeared, that very minute portions of acid or alkaline matter might be disengaged by this means from solid combinations, consisting principally of the pure earths. When cups were used made of a basalt which contained $3\frac{1}{2}$ parts of soda, and nearly half a part of muriatic acid, with fifteen parts of lime in the 100, oxymuriatic acid was found in the positive cup, and a mixture of lime and soda in the other. A cup of compact zeolite, containing seven per cent. of soda, yielded soda and lime to the water connected with the negative wire. Lepidolite yielded potash, and vitreous lava from Etna yielded a mixture of soda, potash, and lime.

Mr. Davy attempted to ascertain whether the weight of the alkali obtained, agreed with the weight lost by the substance operated upon. Water was electrified negatively for four days, by a current from 150 plates, in a glass tube that weighed $84\frac{5}{2}\frac{6}{8}$ grains. The positive wire was inserted into water, contained in an agate cup, and the communication was kept up by moistened amianthus. At the end of the process the glass tube weighed $84\frac{2}{2}\frac{7}{8}$ grains. The water being evaporated, yielded $\frac{3}{2}\frac{7}{8}$ grains of a mixture of soda, with a white powder insoluble in acids.

When soluble compounds were put into water, contained in agate

cups, and electrified, the decomposition was more rapid. A solution of sulphate of potash being put into each of the cups, and electrified by means of fifty pair of plates for four hours, the acid was found by itself in the positive cup, and the alkaline bases in the negative cup. Similar phenomena took place with sulphate of soda, nitrate of potash, nitrate of barytes, sulphate of ammonia, and alum. When muriatic salts were used, these yielded oxymuriatic acid. When compatible mixtures of neutro-saline compounds were used, the different acids and bases separated in a mixed state, without any regard to their affinities. When solutions of metals, deoxidizable by nascent hydrogen were employed, metallic crystals formed on the negative wire, and some oxide was deposited; but solutions of iron, zinc, and tin, only deposited oxide; a great excess of acid was soon observed on the positive side. Although stronger solutions afforded signs of decomposition quicker than weaker ones, yet even the smallest proportions seemed to be acted upon with equal energy: as paper tinged with turmeric was immediately rendered brown when plunged into pure water and brought into contact with the negative point; so paper tinged with litmus was immediately reddened by the positive point, in consequence of the very minute portion of saline matter contained in the paper; and it further appeared, that in all these decompositions the separation of the constituent parts from the last portions of the compounds was complete when the operation was sufficiently protracted.

The contact of the solution with the wires was not necessary for its decomposition; for muriate of potash being put into the middle tube of a series of three, the outer ones containing only water and the wires, alkali soon appeared in that connected with the negative wire, and acid in the other; and at length they were obtained perfectly separate.

In thus causing the acids to be thus transferred from a saline compound into water, through moistened amianthus, no change was observed to take place in litmus paper placed near the amianthus. The reddening of the litmus paper always took place just above the positive point, and then slowly diffused itself to the middle of the vessel. Similar effects were observed when the alkali was transferred, the turmeric paper first becoming brown close to the negative wire.

When three glass tubes were used, the two outer tubes holding a solution of muriate of soda, and the middle one sulphate of silver, a communication being made with the central vessel by turmeric paper on the positive side, and by litmus paper on the negative, neither of the papers had its colour changed, although the muriatic acid passing through the amianthus occasioned a dense heavy precipitate in the sulphate of silver, and the soda a more diffuse and lighter one.

Acid or alkaline substances will also pass through liquids, having a strong attraction for them. In an apparatus of three tubes, Mr. Davy found that sulphuric acid, evolved from sulphate of potash, would pass into water, through either ammonia, lime-water, or weak solutions of potash or of soda. The only effect of strong solutions of

potash or soda was to increase the time necessary for this transfer. Muriatic or nitric acids were also transmitted through alkaline solutions; and, *vice versâ*, alkaline matter, by changing the arrangement of the liquids, was transmissible through the acids: even magnesia was transferred like the other bases. But when it was attempted to pass sulphuric acid through aqueous solutions of barytes or of strontian, on the contrary, the sulphate of those earths was deposited in the intermediate tube.

Muriate of barytes being positive, sulphate of potash intermediate, and water negative, potash appeared in the water, and sulphate of barytes was deposited in the intermediate vessel.

Muriate of barytes being negative, sulphate of silver intermediate, and water positive, sulphuric acid only appeared in the water, and muriate of silver was deposited in the intermediate vessel.

Mr. Davy then proceeds to develop the theory of these phenomena: and he first considers the mode of decomposition and transition. Hydrogen, alkaline substances, and metallic oxides, are attracted by negatively electrified metallic substances, and repelled by positive ones: contrary effects take place with oxygen and the acids. He thinks these electric energies are communicated from one particle to another of the same kind, so as to establish a conducting chain in the fluid, as acid matter is always found in the alkaline solutions through which it is transferred, as long as any acid matter remains at the original source. It is possible that there may be, in some cases, a succession of decompositions and recompositions; but the process is not absolutely necessary, as pure acids and alkalies pass through water to the points by which they are attracted. It appears that this power of transference is overcome by gravity in attempting to pass barytes through sulphuric acid, or muriatic acid through sulphate of silver. To these instances he adds, that magnesia and the metallic oxides will not pass through an intermediate vessel of water, but sink to the bottom.

In the decomposition of water, a particle of oxygen is attracted by the positive point, and at the same time a particle of hydrogen is repelled by it; the opposite process takes place at the negative point: and in the middle of the circuit there must be a new combination of the repelled matter, in the same manner as when two portions of muriate of soda are separated by water; muriatic is repelled from the negative side, and soda from the positive side; so that muriate of soda is composed in the middle vessel.

Although similar effects could not be produced by silently passing a strong current of electricity from an electrical machine for four hours, through sulphate of potash, yet they were produced by using platina wires $\frac{1}{70}$th of an inch in diameter, cemented in glass tubes; so that no doubt can arise but that the principle of action is the same in common as in voltaic electricity.

It was known that many bodies brought into contact and then separated, exhibited opposite states of electricity; and Mr. Davy himself had observed, that when acid and alkaline solutions were em-

ployed in alternation with plates of a single metal, the alkaline solution received the electricity from the metal, and the acid transmitted it to the metal. So in the simplest case of electrical action, the alkali, receiving electricity from the metal, would, on being separated from it, appear positive, and of course be repelled by positively electrified surfaces, and attracted by negatively electrified surfaces; the acid, acquiring the contrary electricity, following the contrary order.

Several phenomena accord with this idea. Sulphur separated from its contact with a metal is positive; and, in like manner, sulphur separated from sulphuric acid by electricity is attracted by the negative surface. And again, hydrogenated sulphuretted alkalies, being composed of three substances, all positive, are so very active in voltaic combinations as, in certain cases, to overpower the energies of the metals.

Mr. Davy then considers the relation between the electrical energy of bodies and their chemical affinities; and observes, that all the substances that combine chemically, exhibit, so far as is known, opposite electric states; and that, in the various experiments of decomposition by electricity, the natural electrical energies of the constituent parts of the compounds acted on are, as it were, overpowered by the artificial electricities: so that it is probable that chemical affinity depends upon the different electrical energies of the acting bodies.

And upon this supposition, particles possessed of opposite electrical states and freedom of motion will enter into combination. When two bodies possessed of the same state act upon a third body possessed of the opposite state, the substance possessing the weakest energy will be repelled. In other cases there may be such a balance of attractive and repellent powers as to produce triple compounds, or even more complicated combinations. It will also be easy to explain the influence of the masses of bodies upon their affinities; for the combined effect of many particles possessing a feeble electrical energy may be conceived equal, or even superior, to the effect of a few particles possessing a strong electrical energy; and, accordingly, we find that concentrated alkalies resist the transmission of acids more powerfully than weak ones.

As the strength of the electricity diminishes from the points to the middle of the water, a measure of the artificial energies may be obtained by the place where the compounds begin to be decomposed. Thus sulphate of barytes requires intermediate contact with the wires; and when 150 pieces of plates were used with a circuit of water of ten inches, sulphate of potash was not decomposed at four inches from the positive wire; but when brought within two inches, its alkali was strongly repelled.

As heat and light are the consequences of a restoration of the equilibrium between bodies in a high state of opposite electricities, so are they also the result of all intense chemical action; and again, as when large quantities of electricity of low intensity act, heat is produced without light, so in low combinations the temperature only is increased. The effect of heat in promoting chemical action seems not

confined to the freedom of motion it gives to the particles, but to the exaltation of the electrical energies of bodies, such as is well known to take place in glass, tourmalin, and sulphur. The electricity of an insulated plate of copper, and a plate of sulphur, was scarcely sensible at 56° Fahr. to the condensing electrometer; at 100° they affected the gold leaves without condensation; they increased in a still higher ratio as the sulphur approached its melting point; and at a little above that point, the two substances rapidly combine, and evolve heat and light. In general, when the different electrical energies are equally strong, the combination seems to be vivid, the heat and light intense, and the new compound is in a neutral state, as in combustion, and the union of the strong acids with the alkalies; but when only the energy is strong, the effect is less vivid, and the compound exhibits the excess of the stronger energy.

Mr. Davy then considers the theory of the Voltaic apparatus; and remarks, that the above facts seem to reconcile Volta's own theory with the chemical theory of galvanism.

In a pile of zinc, copper, and water, the plates are in opposite states of electricity; and in regard to such low electricity, the water is an insulating body. Of course, each plate produces an opposite electricity upon the opposite plate, the intensity increasing with the number, and the quantity with the extent of the series. Upon connecting the extreme points, the opposite electricities tend to produce an equilibrium, which would cause the motion to cease: but the fluid medium being composed of two elements possessing opposite electrical energies, the oxygen is attracted by the zinc, and the hydrogen by the copper. Hence the balance of power is only momentary; for oxide of zinc is formed, and hydrogen is disengaged. The electricity acquired by the copper is communicated anew to the zinc, and the process continues as long as the chemical changes are carried on.

Neither the conducting nor solvent powers of the fluid mediums are a principal cause of their activity; for strong sulphuric acid has very little activity in the pile. The effect of neutro-saline solutions diminishes when troughs are used, according as their acid arranges itself on the side of the zinc plates, and their alkali on the other; but the energy may be restored by agitating the fluids in the cells.

As sensible heat appears when an equilibrium is produced by small metallic surfaces in the voltaic battery, the opposite states being exalted, so if the decomposition of the chemical agents be essential to the balance of the opposed electricities, the decomposition of the saline solutions ought to be attended with an increase of temperature. To water electrified in the gold cones by the power of 100 plates, a drop of solution of potash was added in the positive cone: potash immediately passed over, and in less than two minutes the water was in a state of ebullition. When solution of nitrate of ammonia was employed, the water was evaporated in three or four minutes with a kind of explosive noise, and inflammation took place. The pure alka-

lies, or acids, produced very little effect, although they are better conductors.

Lastly, some general applications of these singular facts are pointed out by Mr. Davy; such, for instance, as the application of electricity to the analysis of animal and vegetable substances. Muscular fibre being electrified for some time, became dry and hard; and it left, upon incineration, no saline matter. Potash, soda, ammonia, lime, and oxide of iron, were collected on the negative side; and the sulphuric, nitric, muriatic, phosphoric, and acetous acids, on the positive. Laurel-leaf was rendered brown and parched; green colouring matter, with resin, alkali, and lime, appeared in the negative vessel, and prussic acid in the positive.

By using charcoal and plumbago, or charcoal and iron, as the exciting powers, along with neutro-saline solutions, large quantities of acids and alkalies might be procured with little trouble or expense.

It is very probable that many mineral formations have been materially influenced or even occasioned by the agency of the electricity; and the electrical power of transference may thus be applied to the explanation of the principal points in geology.

On the Precession of the Equinoxes. By the Rev. Abram Robertson, *M.A. F.R.S. Savilian Professor of Geometry in the University of Oxford.* Read December 18, 1806. [*Phil. Trans.* 1807, *p.* 57.]

The Professor observes, that Sir Isaac Newton was the first mathematician who endeavoured to estimate the quantity of the precession from the attractive influence of the sun and moon on the spheroidal figure of the earth. His investigations relating to this subject evince the same transcendent abilities that are displayed in other parts of his Principia; but it is admitted, that, from a mistake in his process, his conclusion is erroneous.

The investigations of other mathematicians in attempting the solution of the same problem are arranged by the author under three general heads. The first arrive at wrong conclusions, in consequence of mistake in some part of their proceedings; the second obtain just conclusions, but rendered so by balance of opposite errors; the third approach as near the truth as the nature of the subject will admit, but, in the author's estimation, are liable to the charge of obscurity and perplexity.

The defects in all their investigations Professor Robertson ascribes to the same cause—the uncultivated state of the doctrine of compound rotatory motion.

The author's endeavours are, consequently, first directed to the investigation of the principles of compound rotatory motion from principles which he considers clear and unexceptionable.

He next proceeds to calculate the disturbing solar force on the spheroidal figure of the earth, and thence the angular velocity which it produces.

The quantity of annual precession is then computed; and, lastly,